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# Structure of breeding-bird communities on natural and restored Iowa wetlands

Julie Ann Schreiber
*Iowa State University*

Structure of breeding-bird communities on natural

and restored Iowa wetlands

by

Julie Ann Schreiber

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# GENERAL INTRODUCTION

Wetlands, among the most productive and dynamic ecosystems of the world, provide many environmental functions including erosion and flood control, water-quality maintenance, and habitat for fish, waterfowl, and other wildlife (Hubbard 1988). Considered a hindrance to productive land use, large-scale destruction of this ecosystem has resulted in a 53% loss of wetlands nationwide since the 1780s (Dahl 1990). Until recently, this broad range of wetland values including providing nesting habitat for both game and non-game bird species, often was not recognized (Hubbard 1988).

In the mid-1980s, in an attempt to restore wetland conditions to previously drained basins, several large-scale wetland restoration programs were begun. However, few studies have attempted to evaluate the success of wetland restoration. My objective was to compare the breeding-bird community structure and nest-site selection by birds on natural and restored wetlands as a means of evaluating restoration success.

In addition to analyzing the number of breeding-bird species on different wetland types (Delphey and Dinsmore 1993, Hemeseth and Dinsmore 1993, VanRees-Siewert 1993), I used guild analysis to compare the breeding-bird communities of natural and restored wetlands. Since species are assigned to guilds based on resource use rather than taxonomic group, guild analysis may provide additional insight into why certain species, or groups of species, are present in some wetlands and not in others.

## Explanation of Thesis Format

This thesis consists of two papers, each intended for publication in a separate scientific journal. The first paper compares the breeding-bird community structure of natural and restored wetlands, and the second compares nest-site selection between the wetland types. A general summary and literature cited in the general introduction and general summary are included after the two papers. Julie Schreiber helped design the study, conducted the field work, and is the principal author of the papers. Dr. James J. Dinsmore conceived the study idea, assisted in its completion by advising and securing funding for Julie Schreiber, and edited these papers.

# PAPER I. A GUILD ANALYSIS OF BREEDING-BIRD COMMUNITIES ON NATURAL AND RESTORED IOWA WETLANDS

# ABSTRACT

I compared the breeding-bird community structure on 7 natural and 14 restored Iowa wetlands in 1992 and 1993. A total of 14 breeding bird species was found on the study areas in 1992 and 18 species in 1993. Natural wetlands and wetlands restored in 1988 (R-88) had the same number of breeding bird species per wetland in both years (1992, $\overline{X}$ = 7.4; 1993, $\overline{X}$ = 10.9). Wetlands restored in 1991 (R-91) had significantly fewer breeding bird species than natural and R-88 wetlands in both years. Even though natural and R-88 wetlands had the same number of breeding bird species, more natural wetlands had marsh wrens (*Cistothorus palustris*), swamp sparrows (*Melospiza georgiana*), soras (*Porzana carolina*), and Virginia rails (*Rallus limicola*) than either category of restored wetland. Guild analysis showed that when the breeding bird species were grouped functionally, rather than taxonomically, the community structure of natural and restored wetlands was different. Natural wetlands had more omnivores, marsh probers, and elevated-overwater nesters than did restored wetlands in both years. Despite the community differences, however, my results suggest that as restored wetlands age, they are capable of supporting a similar number of breeding bird species as natural wetlands, and given enough time may support similar communities of birds as well.

# INTRODUCTION

The prairie pothole region of North America is a vast prairie-wetland complex containing millions of shallow depressions (Hubbard 1988). Since European settlement, much of this habitat has been altered by agricultural, industrial, and residential development (Tiner 1984). As a region, the Midwest has lost more than half of its wetlands; in Iowa, almost 90% of the wetlands have been drained (Dahl 1990).

These wetlands provide habitat critical for the survival of many game and non-game species (Kantrud et al. 1989). In addition to supporting at least 50% of North American nesting ducks (Batt et al. 1989), more than 30 non-game bird species nest on these wetlands, and many other species depend on them for feeding, loafing, or roosting. In an effort to provide waterfowl habitat, United States and Canadian officials established the North American Waterfowl Management Plan (NAWMP) in 1986 (U.S. Fish and Wildlife Service 1986). The NAWMP is a cooperative effort by federal, state, county, and private organizations to acquire habitat and restore wetlands on private and public lands. In Iowa, wetland restoration by the NAWMP is concentrated in the northern part of the state, with 2,200 hectares of wetlands restored there since 1987 (Neil Heiser, Iowa Department of Natural Resources, pers. commun.).

Although wetland restoration has cost millions of dollars, little has been done to evaluate wildlife use of this habitat. LaGrange and Dinsmore (1989) found that the number of bird species present in restored wetlands of central Iowa was comparable to that found on similar-sized natural wetlands. In northern Iowa, however, fewer species were found on restored wetlands than on natural wetlands with comparable physical and spatial characteristics (Delphey and Dinsmore 1993).

The amount of time required for "successful" restoration of Iowa wetlands is unknown. Delphey (1991) concluded that more than three years are necessary for biotic recovery of previously drained Iowa wetlands. By systematically comparing natural and restored wetlands, it may be possible to evaluate restorations (Delphey and Dinsmore 1993). Beyond this, however, no standard criteria for evaluating restorations are known (Delphey 1991) and it is unclear whether restored wetlands will ever function exactly as natural wetlands do (Delphey and Dinsmore 1993, VanRees-Siewert 1993).

To date, attempts to evaluate wetland restoration have emphasized comparison of the number of species found breeding on restored and natural wetlands (Delphey and Dinsmore 1993). Another way to evaluate these wetlands may be through guild analysis. A guild was first defined as a group of species that uses a particular resource in a similar way (Root 1967).

Many biologists have used guilds to compare or classify different aspects of a community (Willson 1974, Holmes et al. 1979, Landres and MacMahon 1980, Pianka 1980, Croonquist and Brooks 1991, Simberloff and Dayan 1991). Because assigning species to guilds is based on resource use rather than taxonomic group, biologists can use guilds to show interrelations between different taxa. In addition, guilds are useful in understanding how habitat changes affect community dynamics instead of just individual species (De Graff et al. 1985). Guild analysis provides an understanding of why certain species, or groups of species, are present in some wetlands and not in others.

The objective of this study was to evaluate bird use of restored wetlands in northwestern Iowa by:

(1) Comparing the number and species diversity of breeding birds in two age categories of northwestern Iowa restored wetlands with natural wetlands, and

(2) Comparing the guild structure and the number of species within each guild of breeding birds in natural and restored wetlands.

# METHODS

## Study Area

I studied natural and restored wetlands in northwestern Iowa (Table A-1). Wetlands were selected based on age, size, percent emergent vegetation cover, land-use history, and degree of isolation.

I examined seven wetlands in each of three categories: unaltered natural, restored/first flooded in 1988 (R-88), and restored/first flooded in 1991 (R-91). Wetlands ranged from 0.8-3.0 ha (Table A-2). All wetlands selected in 1992 were in the hemi-marsh stage (40-60% emergent vegetation), the wetland type with maximum bird diversity (Weller and Spatcher 1965, Weller and Fredrickson 1974). By 1993, several of the wetlands chosen in 1992 had more than 60% emergent vegetation, but these wetlands were kept in the study to allow year-to-year comparisons. In addition, all restored wetlands selected met the following historical land-use criteria: (1) complete drainage of wetland basin prior to restoration, (2) drained with drainage tile, and (3) row cropped while basin was drained. Finally, to reduce isolation effects (Brown and Dinsmore 1986), all wetlands chosen for this study were part of wetland complexes.

## Bird Community Composition

On each wetland I established three census stations in the middle of the emergent vegetation zone, or at the water's edge if no emergent zone was present. The first station was positioned using a random compass bearing, and the other two stations were spaced evenly around the wetland.

I visited each wetland six times during the nesting season (May-July) to assess breeding bird use. Bird surveys were completed between sunrise and 0900 using a systematic census order to eliminate time-of-day bias (Skirvin 1981). All birds seen or heard during a 6-minute counting period within an 18-m radius of each census station center were recorded (Edwards et al. 1981). Midway through each observation period I played a 2-minute tape recording of sora (*Porzana carolina*), Virginia rail (*Rallus limicola*), least bittern (*Ixobrychus exilis*), and American bittern (*Botaurus lentiginosus*) calls to elicit their response (Marion et al. 1981, Gibbs and Melvin 1993). I also noted birds seen or heard on the wetlands outside the counting period.

A species was considered to be breeding in a wetland if an active nest or eggs were found, flightless young were seen, or adults were seen on at least 50% of all visits to a wetland. Based on the local breeding phenology of sora and Virginia rails (Tanner and Hendrickson 1954, 1956, Johnson and Dinsmore 1986, Kaufmann 1989), if either species was present during two of the first four visits to a wetland, it was considered to be breeding there. Similarly, if American or least bitterns were present during two of the last four visits to a wetland, they were considered to be breeding (Provost 1947, Gibbs and Melvin 1993).

## Guild Structure

Birds were assigned to guilds using a classification of foraging guilds of North American birds (De Graff et al. 1985, Ehrlich et al. 1988). Guild assignments of breeding birds were made based on resource and habitat partitioning during the breeding season (Horak 1970; Swanson et al. 1979; Swanson 1985; Gibbs et al. 1992a, 1992b). Guild types included in this study were food type (carnivore, herbivore, insectivore, omnivore) (see Table A-3), foraging method (ambusher, dabbler, diver, marsh gleaner, prober, upland forager), and nest site (edge, muskrat lodge, overwater - at surface, overwater - elevated, upland) (see Table A-3).

## Data Analysis

Because of the small sample size and unknown variances, I used the Wilcoxon rank-sum test to compare the mean number of breeding bird species on natural, R-88, and R-91 wetlands. The Fisher exact test was used to compare the proportions of natural and restored wetlands used by each breeding bird species. This test is preferable to chi-square in contingency table analysis when at least one cell value is less than one or when more than 20% are less than five (Zar 1984:70). Guild data were analyzed using the Wilcoxon rank-sum test. PC-SAS (SAS Institute 1988) and a significance level of $p \leq 0.05$ were used for all statistical tests.

# RESULTS

## Breeding Bird Wetland Use

A total of 14 breeding bird species was found on the study areas in 1992 and 18 species in 1993 (see Tables A-4, A-5). In both 1992 and 1993, the mean number of breeding bird species found on natural and R-88 wetlands was the same (Table 1). Significantly fewer breeding bird species were found on R-91 wetlands than the other two categories in both years.

I intended to make between-year comparisons of the number of breeding bird species on R-88 and R-91 wetlands, but the differences in rainfall levels in 1992 and 1993 precluded me from doing so. Total spring rainfall (April-June) in Dickinson and Emmet counties was below the 30-year average (-2.69 and -6.04 cm respectively) in 1992 and far above the 30-year average (+32.49 and +37.81 cm respectively) in 1993 (NOAA 1992, 1993). Comparing the mean number of breeding bird species on natural, R-88, and R-91 wetlands between years, I found significantly more species nesting on all three wetland types in 1993 than in 1992 (Table 1).

## Breeding Bird Wetland Selection

Red-winged blackbirds (*Agelaius phoeniceus*) and common yellowthroats (*Geothlypis trichas*) nested on more than 90% of the wetlands in both years. In 1993, the Canada goose

Table 1. Mean number of breeding bird species found on natural and restored Iowa wetlands

| Wetland Type | 1992 | | | 1993 | |
|---|---|---|---|---|---|
| Natural | 7.4 | A[1] | *[2] | 10.9 | A |
| 1988 Restored | 7.4 | A | * | 10.9 | A |
| 1991 Restored | 3.9 | B | * | 7.7 | B |

[1]Values within columns with different letters are statistically different, Wilcoxon rank sum test, $p \leq 0.05$
[2]Mean number of breeding bird species is statistically different within wetland class between years, Wilcoxon rank sum test, $p \leq 0.05$

(Branta *canadensis*) nested on 70% of all wetland basins in the study.

In contrast, several other species nested on the three wetland types to different degrees. In 1992, blue-winged teal (*Anas discors*) and mallards (*A. platyrhynchos*) used R-88 wetlands more often than natural wetlands (Table 2). More natural wetlands, however, had breeding Virginia rails than R-91 wetlands, and more marsh wrens (*Cistothorus palustris*) than either age class of restored wetland. Yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) nested significantly more often on natural than R-91 wetlands.

Similarly, in 1993, several non-game marsh bird species nested more often on natural wetlands than on at least one of the two restored wetland categories (Table 3). Soras and swamp sparrows (*Melospiza georgiana*) nested on significantly more natural than R-91 wetlands, breeding marsh wrens used natural wetlands more than R-88 wetlands, and Virginia rails nested significantly more often on natural wetlands than on either age category of restored wetland. The American coot (*Fulica americana*) nested more often on natural and R-88 wetlands than on R-91 wetlands. Sedge wrens (*Cistothorus platensis*) nested on restored wetlands exclusively.

Table 2. Proportion of natural and restored wetlands at which selected species were considered breeding, 1992

| Species | Wetland Type: Natural (n=7) | 1988 Restored (n=7) | 1991 Restored (n=7) |
|---|---|---|---|
| Mallard | 1/7 | 6/7 | 5/7 |
| | A[1] | B | AB |
| Blue-winged teal | 2/7 | 7/7 | 6/7 |
| | A | B | AB |
| Virginia rail | 6/7 | 2/7 | 0/7 |
| | A | A | B |
| Marsh wren | 6/7 | 1/7 | 0/7 |
| | A | B | B |
| Yellow-headed blackbird | 7/7. | 6/7 | 2/7 |
| | A | AB | B |

[1]Values within rows with different letters are statistically different, Fisher's exact test (2-tailed), $p \leq 0.05$

Table 3. Proportion of natural and restored wetlands at which selected species were considered breeding, 1993

| Species | Wetland Type: Natural (n=7) | 1988 Restored (n=7) | 1991 Restored (n=7) |
| --- | --- | --- | --- |
| Virginia rail | 7/7 | 2/7 | 0/7 |
| | A[1] | B | B |
| Sora | 6/7 | 2/7 | 0/7 |
| | A | AB | B |
| American coot | 7/7 | 7/7 | 2/7 |
| | A | A | B |
| Sedge wren | 0/7 | 7/7 | 7/7 |
| | A | B | B |
| Marsh wren | 7/7 | 2/7 | 3/7 |
| | A | B | AB |
| Swamp sparrow | 6/7 | 2/7 | 1/7 |
| | A | AB | B |

[1]Values within rows with different letters are statistically different, Fisher's exact test (2-tailed), $p \leq 0.05$

## Food-type Guilds

The breeding bird food-type guilds of the three wetland types differed in several ways. In 1992, more carnivores nested on R-88 wetlands than on natural wetlands (Table 4). Natural and R-88 wetlands had more insectivores than R-91 wetlands. More omnivores nested on natural wetlands than on R-91 wetlands.

Similar to 1992, in 1993, more carnivores nested on R-88 wetlands than on natural wetlands (Table 5). Natural wetlands had significantly more herbivores than did either type of restored wetland. The number of omnivores was significantly different in each of the 3 wetland categories; natural wetlands had the most and R-91 the least. The dominant guild, insectivores, was equally common in all three wetland types.

## Foraging-method Guilds

When bird species were grouped by foraging method, I found several differences among the three wetland types. In 1992, significantly more dabblers nested on R-88 wetlands than on natural wetlands (Table 6). Both natural and R-88 wetlands had significantly more breeding birds in the marsh-gleaner guild than did R-91 wetlands. Natural wetlands had significantly more marsh-probing and upland-foraging species than the R-91 wetlands.

Table 4. Mean number of breeding bird species assigned to food-type guilds in each wetland type, 1992

| Food-type Guild | Natural (n=7) | 1988 Restored (n=7) | 1991 Restored (n=7) |
|---|---|---|---|
| | **Wetland Type** | | |
| Carnivore | 1.0 | 2.9 | 1.7 |
| | A[1] | B | AB |
| Insectivore | 4.4 | 3.4 | 1.7 |
| | A | A | B |
| Herbivore | 0.6 | 0.1 | 0.1 |
| | A | A | A |
| Omnivore | 1.4 | 1.0 | 0.3 |
| | A | AB | B |

[1]Values within rows with different letters are statistically different, Wilcoxon rank sum test, $p \leq 0.05$

Table 5. Mean number of breeding bird species assigned to food-type guilds in each wetland type, 1993

| Food-type Guild | Natural (n=7) | 1988 Restored (n=7) | 1991 Restored (n=7) |
|---|---|---|---|
| | Wetland Type | | |
| Carnivore | 2.3 | 4.0 | 2.4 |
| | A[1] | B | AB |
| Insectivore | 4.9 | 4.6 | 4.4 |
| | A | A | A |
| Herbivore | 1.7 | 1.0 | 0.6 |
| | A | B | B |
| Omnivore | 2.0 | 1.3 | 0.3 |
| | A | B | C |

[1]Values within rows with different letters are statistically different, Wilcoxon rank sum test, $p \leq 0.05$

Table 6. Mean number of breeding bird species assigned to foraging-method guilds in each wetland type, 1992

| Foraging-method Guild | Wetland Type: Natural (n=7) | 1988 Restored (n=7) | 1991 Restored (n=7) |
|---|---|---|---|
| Freshwater dabbler | 1.4 | 2.7 | 2.0 |
| | A[1] | B | AB |
| Freshwater diver | 0.6 | 0.9 | 0.1 |
| | A | A | A |
| Marsh gleaner | 4.4 | 3.4 | 1.7 |
| | A | A | B |
| Marsh prober | 1.0 | 0.3 | 0 |
| | A | AB | B |
| Water ambusher | 0 | 0.1 | 0 |
| | A | A | A |
| Upland forager | 3.4 | 3.0 | 1.9 |
| | A | AB | B |

[1]Values within rows with different letters are statistically different, Wilcoxon rank sum test, $p \leq 0.05$

In 1993, the only significant difference in foraging method guilds was that marsh probers nested on significantly more natural wetlands than on either category of restored (Table 7). No marsh probers nested in the R-91 wetlands in either year.

## Nest-site Guilds

Based on nest-site requirements, different numbers of bird species nested on the three wetland types. In 1992, more edge-nesting bird species were found in natural and R-88 wetlands than in R-91 wetlands (Table 8). Significantly more species that had elevated-overwater nests were found on natural than on either category of restored wetlands. Fewer upland-nesting birds were found on natural wetlands than on R-88 wetlands.

In 1993, more edge-nesting birds were found on natural than R-91 wetlands (Table 9). R-88 wetlands had significantly more overwater surface-nesting birds than R-91 wetlands. By 1993, the increase in the number of species that had elevated-overwater nests in R-91 wetlands made R-91 wetlands comparable to the R-88 wetlands, but natural wetlands still had more breeding species in this guild than either of the two restored wetland groups. As in 1992, R-88 wetlands had significantly more upland-nesting species than did natural wetlands.

Table 7. Mean number of breeding bird species assigned to foraging-method guilds in each wetland type, 1993

| Foraging-method Guild | Wetland Type: Natural (n=7) | 1988 Restored (n=7) | 1991 Restored (n=7) |
|---|---|---|---|
| Freshwater dabbler | 2.6 | 3.9 | 2.6 |
| | A[1] | A | A |
| Freshwater diver | 1.0 | 1.6 | 0.6 |
| | A | A | A |
| Marsh gleaner | 4.9 | 4.6 | 4.4 |
| | A | A | A |
| Marsh prober | 1.9 | 0.6 | 0 |
| | A | B | C |
| Water ambusher | 0.6 | 0.3 | 0.1 |
| | A | A | A |
| Upland forager | 3.9 | 3.7 | 3.4 |
| | A | A | A |

[1]Values within rows with different letters are statistically different, Wilcoxon rank sum test, $p \leq 0.05$

Table 8. Mean number of breeding bird species assigned to nest-site guilds in each wetland type, 1992

| Nest-site Guild | Wetland Type: Natural (n=7) | Wetland Type: 1988 Restored (n=7) | Wetland Type: 1991 Restored (n=7) |
|---|---|---|---|
| Edge | 4.0 | 3.0 | 1.6 |
| | A[1] | A | B |
| Muskrat lodge | 1.0 | 0.9 | 0.6 |
| | A | A | A |
| Overwater - at surface | 1.1 | 1.7 | 0.4 |
| | A | A | A |
| Overwater - elevated | 2.9 | 2.0 | 1.0 |
| | A | B | B |
| Upland | 0.4 | 1.9 | 1.6 |
| | A | B | AB |

[1]Values within rows with different letters are statistically different, Wilcoxon rank sum test, $p \leq 0.05$

Table 9. Mean number of breeding bird species assigned to nest-site guilds in each wetland type, 1993

| Nest-site Guild | Wetland Type: Natural (n=7) | 1988 Restored (n=7) | 1991 Restored (n=7) |
|---|---|---|---|
| Edge | 5.9 | 4.9 | 3.7 |
| | A[1] | AB | B |
| Muskrat lodge | 1.4 | 1.1 | 1.0 |
| | A | A | A |
| Overwater - at surface | 2.3 | 3.0 | 1.0 |
| | AB | A | B |
| Overwater - elevated | 3.3 | 2.3 | 2.4 |
| | A | B | B |
| Upland | 0.7 | 2.0 | 1.7 |
| | A | B | AB |

[1]Values within rows with different letters are statistically different, Wilcoxon rank sum test, $p \leq 0.05$

## Comparison of Species Pairs

I reviewed the species composition of each guild, comparing all possible species pairs, and discovered two instances that suggest that the presence of one breeding bird species on a wetland may restrict another species in that guild from nesting there. American bitterns and least bitterns never nested on the same wetland, but both species nested on two different natural wetlands in 1993 (Tables A-4, A-5). Furthermore, sora and Virginia rail never nested on the same restored wetland, but were found nesting together on natural wetlands in both years.

# DISCUSSION

## General Breeding Bird Use

The mean number of breeding bird species using natural and older restored Iowa wetlands (i.e., R-88 wetlands) was equal (1992=7.4, 1993=10.9). Similar results were found by LaGrange and Dinsmore (1986) on central Iowa restored wetlands. Other studies comparing the bird communities of northern Iowa wetlands found more species nesting on natural than on restored wetlands (Delphey and Dinsmore 1993, VanRees-Siewert 1993).

It is not surprising that R-91 wetlands had significantly fewer breeding bird species than natural wetlands in both years. Previous studies have suggested that the low breeding-bird use of recently restored wetlands can at least be partly attributed to the relative lack of vegetation on these young restored wetlands (Delphey and Dinsmore 1993, VanRees-Siewert 1993). Although I did not measure vegetative cover, during my weekly visits to the study areas I noted that the natural wetlands had more cover and vegetation diversity than the R-91 wetlands.

Similar to the natural wetlands, the R-88 wetlands had significantly more breeding bird species than the R-91 wetlands in both years. In her study of restored northern Iowa wetlands, VanRees-Siewert (1993) concluded that as the wetlands age, both the amount and complexity of vegetative cover and the number of breeding bird species increase. My results support VanRees-Siewert's conclusion.

More breeding bird species were found on all three wetland types in 1993 than in 1992 (Table 1). Since both groups of restored wetlands were "older" in 1993 and had better developed stands of emergent vegetation, this probably accounted for some of the increase in species number (VanRees-Siewert 1993). However, since the number of species also increased on natural wetlands, which I noted showed little change in vegetative cover between years, it is likely that other factors were also involved. Precipitation levels were below normal in 1992 and far above normal in 1993; most of the wetlands in the study were noticeably deeper in 1993 than in 1992. The difference in water levels between years most likely contributed to the increase in the average number of breeding bird species in all three wetland categories.

## Wetland Selection

Even though the number of breeding bird species using natural and R-88 wetlands was equal in both years, when presence or absence of individual species in different wetland types was analyzed, it became obvious that the basic community structure of restored and natural wetlands was different.

Unlike Delphey and Dinsmore's (1993) findings that the number of waterfowl species breeding on natural and restored wetlands was not significantly different, my results indicate that some species of waterfowl, at least, prefer restored to natural wetland habitat (Table 2). VanRees-Siewert (1993) found that the number of breeding waterfowl species was the same for each of four different age groups of restored wetlands. It is not surprising that blue-winged teal and mallard, two of Iowa's most common nesting waterfowl, were found on nearly all of the restored wetlands in 1992, as waterfowl often use areas of open water as soon as they are available (Delphey 1991, VanRees-Siewert 1993). Blue-winged teal and mallard may have preferred restored wetlands because they had larger open water areas than natural wetlands whose vegetative structure was generally more complex.

Four typical marsh-bird species nested more often on natural wetlands than either age of restored wetland in both years of the study (Tables 2,3). In both 1992 and 1993, the Virginia rail, sora, marsh wren, and swamp sparrow nested on natural wetlands significantly more than on at least one of the two age categories of restored wetlands. All four species typically nest in emergent vegetation, a habitat that was well-developed in the natural wetlands, but was also fairly well established in many of the restored basins, especially by the second year of the study. One important vegetative zone that was missing from all restored wetlands in my study, but present at all natural wetlands was wet meadow (Delphey 1991, Galatowitsch 1993, VanRees-Siewert 1993). Species such as swamp sparrow, sedge wren, common yellowthroat, marsh wren, sora, and Virginia rail are known to prefer wet-meadow areas for nesting (Tanner and Hendrickson 1954, 1956; Weller and Spatcher 1965; Kantrud and Stewart 1984; Johnson and Dinsmore 1986; Delphey 1991). The lack of a wet-meadow zone may prevent these species from nesting on restored wetlands. If this is the case, active planting of wet-meadow species may be necessary before marsh-birds dependent on wet-meadow zones are able to breed on restored wetlands (Galatowitsch 1993).

There were also a few species that nested more often on natural and/or R-88 wetlands than on R-91 wetlands. Probably most, if not all, of these differences can be explained by the vegetative structure of the three wetland age groups. Although yellow-headed blackbirds nested significantly more often on natural and R-88 wetlands than on R-91 wetlands in 1992, by 1993, all 21 wetland basins had nesting yellow-headed blackbirds. Because yellowheads nest in well developed stands of emergent vegetation, the increase in yellow-headed blackbirds nesting on R-91 wetlands in 1993 supports studies indicating that the emergent-vegetation zone is readily re-established in restored wetlands (Delphey 1991, Galatowitsch 1993, VanRees-Siewert 1993).

It is interesting that the American coot nested less frequently on R-91 wetlands than the other two wetland age classes in 1993. Weller and Fredrickson (1974) found that coots adapted well to newly flooded, sparsely vegetated wetlands, but that as vegetation density increased, coot populations decreased. I observed that as restored wetlands aged, the amount of emergent vegetation increased such that oftentimes, the wetland basin had few areas of open water; open areas necessary for nesting swimming birds, such as coots. If coots prefer to nest in the newly flooded, sparsely vegetated habitat that Weller and Fredrickson (1974) described, I would have expected coots to nest more often on the newly flooded, sparsely vegetated R-91 wetlands.

Surprisingly, the sedge wren nested exclusively on both age classes of restored wetlands in 1993. Although sedge wrens typically nest in wet-meadows, a vegetation zone absent from all restored wetlands, they will also nest in other dense nesting cover such as the CRP fields or similar cover that surrounded all restored wetlands I studied (pers. observ.).

## Guild Analysis

Analysis of breeding bird species using food-type, foraging-method, and nest-site guilds may provide added insight into the community composition of different wetland types. Because guild analysis looks at the functional role of the birds rather than taxonomic group, it may help explain why certain species are present more often in some wetland types than in others.

In both years, the insectivore guild was the best represented food-type guild in natural wetlands (Tables 4,5). Although this guild was fairly well represented in both age categories of restored wetlands, the carnivore guild also had a comparable number of species in restored wetlands. In 1992, significantly more insectivores used natural and R-88 wetlands than R-91 wetlands, but in 1993, there were no differences in insectivore use between these three wetland types. Although invertebrates rapidly recolonize restored wetlands (Delphey 1991, VanRees-Siewert 1993), perhaps there is a lag in invertebrate recolonization which limits the number of insectivorous birds that can nest on 1-year-old restored wetlands.

In both years, there were significantly more omnivores nesting on natural than R-91 wetlands, and in 1993, R-88 wetlands had significantly fewer omnivores than the natural wetlands did as well. Perhaps a greater diversity or amount of resources is available to birds on natural than on restored wetlands. Furthermore, the greater variety of herbivores using natural wetlands in 1993 may indicate that the food supply available for herbivores is more limited in restored wetlands.

The most consistent difference in terms of the foraging method guild analysis is in the marsh-prober guild. In 1992, natural wetlands had significantly more marsh probers than R-91 wetlands, and in 1993, natural wetlands had more probers than either age category of restored wetland. This suggests that the habitat needed by the two species in this guild, the sora and Virginia rail, while present in the natural wetlands, is still missing from the restored wetlands, even five years after restoration. Despite their similar use of habitat and foraging methods, sora and Virginia rail do not compete for food (Horak 1970, Johnson and Dinsmore 1986). Therefore, another unknown microhabitat variable may restrict marsh-probing species from nesting on restored wetlands.

Although too few American (*Botaurus lentiginosus*) and least bitterns (*Ixobrychus exilis*) nested on the study areas to show significant statistical trends, when they did nest, the two species never nested on the same wetlands. Gibbs et al. (1992) found that although interactions between the two bittern species may be minimal because of different microhabitat requirements, both species often breed at the same wetland. In Brown's study of natural wetlands in northwestern Iowa (1985), both species of bittern nested individually on various wetlands, but they nested together on only one wetland (18.6 ha). Perhaps the wetlands in my study were not large enough to support both species of nesting bittern.

There were significantly more marsh gleaners breeding on natural and R-88 wetlands than on R-91 wetlands in 1992, but by 1993, there were no differences in marsh gleaner use of the three wetland categories. As species that largely obtain their food by gleaning it off the surface of emergent vegetation, the scarcity of these birds on the R-91 wetlands, wetlands with limited emergent vegetation growth, is not surprising. The fairly equal representation of marsh gleaners on all three wetland types in 1993 suggests that the emergent vegetation on R-91 wetlands is similar to that on natural and older restored wetlands. All six species assigned to the marsh-gleaner guild were also all assigned to the insectivore food-type guild. This overlap in classification may make it impossible to discern whether food type or foraging method is influencing where these birds are found.

There were also significantly more upland foraging birds using natural wetlands than R-91 wetlands in 1992. This most likely reflects a difference in the upland vegetative structure near natural and R-91 wetlands. Although all uplands around the restored wetlands in this study were planted to a variety of non-native cool-season grasses, the period of time needed for these grasses to become established may make uplands near R-91 wetlands less desirable to upland foragers than older restored and natural wetlands. By their second year, the number of upland foragers on R-91 wetlands did not differ significantly from either of the other two wetland types. This is encouraging as one of the primary goals of the North American Waterfowl Management Plan is to increase the number of upland-nesting dabbling ducks.

I found significantly more edge-nesting species on natural than R-91 wetlands in both years. This in itself may not be too surprising considering the vegetation differences on natural and young restored wetland basins. It was surprising, however, to find no clear differences between the natural and restored wetlands overall in edge-nesting species. I expected that the absence of a wet-meadow zone on all restored wetlands (Delphey 1993, Galatowitsch 1993, VanRees-Siewert 1993) might have produced a more obvious effect on the number of edge-nesting species using restored versus natural wetlands. My grouping of edge-nesting species, however, combined more sensitive edge-nesting species (sora, Virginia rail) with some of the more ubiquitous marsh species (common yellowthroat, red-winged blackbird). As a result, the wet-meadow microhabitat required by the sora and Virginia rail may not have been delineated enough from different types of edge microhabitat used by other species assigned to the edge-nesting guild.

There were significantly more elevated-overwater nesting species in natural wetlands than either age category of restored wetland in both years. It was surprising that natural wetlands had more elevated-overwater nesters than the R-88 wetlands. VanRees-Siewert (1993) found that in most cases, emergent vegetation was well established by the time a restored wetland was 4 years old. I observed this trend as well in my study areas; both 4- and 5-year old wetlands had extensive stands of emergent vegetation. If the number of elevated overwater nesters was affected only by the presence or absence of emergent vegetation, there should be no difference in the number of breeding bird species in this guild in natural and older restored wetlands. The fact that this difference does exist suggests that it is more than the presence or absence of emergent vegetation that affects the species composition of natural and restored wetlands.

Although my results indicate that natural and older restored Iowa wetlands can support a similar number of breeding bird species, when the species composition of these two wetland types was compared, the community structure of natural and restored wetlands differed significantly. At this point, the factors influencing species composition of bird communities on natural and restored wetlands are largely unknown. A more detailed study comparing the bird community structure to the vegetative structure and other physical characteristics of natural and restored wetlands is needed in order to further elucidate the differences between natural and restored wetlands. It is not until we have a better idea of how these two wetland groups differ that we can work more effectively at making them the same.

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APPENDIX

Table A-1. LANDOWNER AND LOCATION OF STUDY SITES

| ID | Landowner/title | County | Township/Range/Section |
|---|---|---|---|
| 1 | Spring Run SE | Dickinson | T99N R36W S24 NE1/4 |
| 2 | Spring Run NW | Dickinson | T99N R36W S24 NE1/4 |
| 15 | Thu | Palo Alto | T97N R34W S8 NW1/4 |
| 16 | E. Jemmerson West | Dickinson | T100N R36W S32 SW1/4 |
| 17 | E. Jemmerson East | Dickinson | T100N R36W S32 SW1/4 |
| 19 | Henry | Emmet | T98N R34W S36 SW1/4 |
| 20 | McBreen East | Dickinson | T100N R37W S13 SW1/4 |
| 21 | Love | Emmet | T99N R34W S7 NE1/4 |
| 22 | Clay Restored South | Clay | T97N R35W S26 NE1/4 |
| 23 | Clay Restored North | Clay | T97N R35W S26 NE1/4 |
| 24 | Dewey's Pasture, C2 | Clay | T97N R35W S25 NE1/4 |
| 25 | Dewey's Pasture, A6 | Clay | T97N R35W S25 NW1/4 |
| 26 | Kossuth Natural | Kossuth | T100N R30W S7 NE1/4 |
| 27 | Grover | Dickinson | T100N R37W S12 SW1/4 |
| 30 | McBreen North | Dickinson | T100N R37W S13 SW1/4 |
| 33 | 3-Corners Pond | Dickinson | T99N R37W S34 SE1/4 |
| A | Appel | Palo Alto | T97N R33W S31 NE1/4 |
| F | Silver Lake Fen | Dickinson | T100N R38W S32 NW1/4 |
| G | Graff | Dickinson | T99N R37W S34 NE1/4 |
| K | Kossuth Restored | Kossuth | T100N R30W S7 NW1/4 |
| S | Siemers | Palo Alto | T97N R34W S3 SW1/4 |
| W | Westergard | Dickinson | T99N R36W S9 NE1/4 |

Table A-2. TYPE AND AREA (HA) OF STUDY SITES

| ID | Landowner/title | Type | Area (Ha) |
|---|---|---|---|
| 1 | Spring Run SE | Natural | 1.9 |
| 2 | Spring Run NW | Natural | 1.2 |
| 15 | Thu | 1988 Restored | 1.5 |
| 16 | E. Jemmerson West | 1991 Restored | 1.5 |
| 17 | E. Jemmerson East | 1991 Restored | 0.8 |
| 19 | Henry | 1988 Restored | 1.0 |
| 20 | McBreen East | 1988 Restored | 2.5 |
| 21 | Love | 1988 Restored | 2.0 |
| 22 | Clay Restored South | 1991 Restored | 1.0 |
| 23 | Clay Restored North | 1991 Restored | 0.9 |
| 24 | Dewey's Pasture, C2 | Natural | 1.9 |
| 25 | Dewey's Pasture, A6 | Natural | 1.7 |
| 26 | Kossuth Natural | Natural | 2.0 |
| 27 | Grover | Natural | 2.1 |
| 30 | McBreen North | 1988 Restored | 2.7 |
| 33 | 3-Corners Pond | Natural | 2.5 |
| A | Appel | 1988 Restored | 2.0 |
| F | Silver Lake Fen | Natural | 2.1 |
| G | Graff | 1991 Restored | 0.8 |
| K | Kossuth Restored | 1991 Restored | 3.0 |
| S | Siemers | 1988 Restored | 1.1 |
| W | Westergard | 1991 Restored | 0.8 |

Table A-3. FOOD-TYPE, FORAGING-METHOD, AND NEST-SITE GUILD ASSIGNMENTS OF BREEDING BIRD SPECIES

| Species | Food Type[1] | Foraging Method | Nest Site |
|---|---|---|---|
| American bittern | Carnivore | Water ambusher | Edge<br>Overwater -surface |
| American coot | Omnivore | Freshwater dabbler | Overwater -surface |
| Blue-winged teal | Carnivore | Freshwater dabbler | Upland |
| Canada goose | Herbivore | Upland forager<br>Freshwater dabbler | Edge<br>Muskrat lodge |
| Common yellowthroat | Insectivore | Upland forager<br>Marsh gleaner | Edge |
| Least bittern | Carnivore | Water ambusher | Overwater -elevated |
| Mallard | Carnivore | Freshwater dabbler | Upland<br>Muskrat lodge |
| Marsh wren | Insectivore | Marsh gleaner | Overwater -elevated |
| Northern shoveler | Carnivore | Freshwater dabbler | Upland |
| Pied-billed grebe | Carnivore | Freshwater diver | Overwater -surface |
| Redhead | Carnivore | Freshwater diver | Overwater -surface |
| Red-winged blackbird | Insectivore | Upland forager<br>Marsh gleaner | Edge<br>Overwater -elevated |
| Ruddy duck | Carnivore | Freshwater diver | Overwater -surface |
| Sedge wren | Insectivore | Marsh gleaner | Edge |

Table A-3 cont.

| Species | Food Type | Foraging Method | Nest Site |
|---|---|---|---|
| Sora | Herbivore | Marsh prober | Edge |
| Swamp sparrow | Insectivore | Marsh gleaner | Edge |
| Virginia rail | Omnivore | Marsh prober | Edge |
| Yellow-headed blackbird | Insectivore | Marsh gleaner<br>Upland forager | Overwater<br>-elevated |

[1]Guild assignments based on food eaten during the breeding season:

- Carnivore = predominantly fish, mollusks, crustaceans, or insects in the water column (70%+ of diet)
- Herbivore = predominantly plant matter (plants make up at least 70% of the diet)
- Insectivore = predominantly insects gleaned off of emergent vegetation or airborne (70%+ of diet)
- Omnivore = significant amount of both plant and animal matter (not more than 70% of either)

Table A-4. SUMMARY OF BIRD SPECIES BREEDING ON NATURAL AND RESTORED IOWA WETLANDS, 1992

| | Wetland Type | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Natural | | | | | | | 1988 Restored | | | | | | | 1991 Restored | | | | | | |
| Species | 1 | 2 | 24 | 25 | 26 | 27 | F | 15 | 19 | 20 | 21 | 30 | A | S | 16 | 17 | 22 | 23 | G | K | W |
| RWB[1] | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | X | X | X | X | |
| CYT | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | X | |
| YHB | X | X | X | X | X | X | X | X | X | X | | X | X | X | | | | X | | X | |
| BWT | | | | X | | | X | X | X | X | X | X | X | X | X | X | X | | X | X | X |
| MAL | | | | | | | X | X | | X | X | X | X | X | X | X | | | X | X | X |
| AMC | X | X | | X | X | | | X | X | X | | | X | X | | | X | | X | | |
| PBG | | | X | X | X | X | | X | X | X | | | X | X | | | | | X | | |
| VAR | X | X | X | X | X | X | | X | X | | | | | | | | | | | | |
| MWR | X | X | X | X | X | X | | | | | | X | | | | | | | | | |
| SWS | | X | X | X | X | | | X | | | | X | X | | | | | | | | |
| CAG | | X | | X | X | | | | | | X | | | | | | | | | X | |
| SOR | | | X | | | | | | | | | | | | | | | | | | |
| AMB | | | | | | | | | | | | | X | | | | | | | | |
| RDU | | | | | | | | | | | | | X | | | | | | | | |

[1]RWB = Red-winged blackbird
CYT = Common yellowthroat
YHB = Yellow-headed blackbird
BWT = Blue-winged teal
MAL = Mallard
AMC = American coot
PBG = Pied-billed grebe
VAR = Virginia rail
MWR = Marsh wren
SWS = Swamp sparrow
CAG = Canada goose
SOR = Sora
AMB = American bittern
RDU = Ruddy duck

Table A-5. SUMMARY OF BIRD SPECIES BREEDING ON NATURAL AND RESTORED IOWA WETLANDS, 1993

| | Wetland Type | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Natural | | | | | | | 1988 Restored | | | | | | | 1991 Restored | | | | | | |
| Species | 1 | 2 | 24 | 25 | 26 | 27 | 33 | 15 | 19 | 20 | 21 | 30 | A | S | 16 | 17 | 22 | 23 | G | K | W |
| RWB[1] | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| YHB | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| CYT | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | X | X |
| BWT | | X | X | | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| AMC | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | X | X | |
| CAG | X | X | X | X | X | | X | X | X | | X | X | X | | X | | X | X | | X | |
| SWR | | | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| MWR | X | X | X | X | X | X | X | X | | | | X | | | X | | X | X | | | |
| PBG | X | | X | | | X | X | | X | X | X | X | X | X | | | X | | | X | |
| MAL | | | | | X | | | X | X | X | X | | X | | X | X | | | X | X | |
| VAR | X | X | X | X | X | X | X | | X | | | | X | | | | | | | | |
| SWS | X | X | X | X | X | X | | X | | | | | X | | X | | | | | | |
| SOR | X | | X | X | X | X | X | | | X | | | | X | | | | | | | |
| RED | X | X | | | | X | | X | | | X | X | | | | | X | | | | |
| AMB | X | | X | | | | | | | | | X | X | | | | | | | X | |
| RDU | | | | | | | | | | X | X | X | | | | | | | | X | |
| SHO | | | | | | | | X | | | X | | | | | | | | X | | |
| LBT | | X | | X | | | | | | | | | | | | | | | | | |

[1]RWB = Red-winged blackbird
YHB = Yellow-headed blackbird
CYT = Common yellowthroat
BWT = Blue-winged teal
AMC = American coot
CAG = Canada goose
SWR = Sedge wren
MWR = Marsh wren
PBG = Pied-billed grebe
MAL = Mallard
VAR = Virginia rail
SWS = Swamp sparrow
SOR = Sora
RED = Redhead
AMB = American bittern
RDU = Ruddy duck
SHO = Northern shoveler
LBT = Least bittern

# PAPER II. NEST-SITE SELECTION BY BIRDS ON NATURAL AND RESTORED IOWA WETLANDS

## ABSTRACT

I compared nest-site selection in marsh-nesting birds on 7 natural and 14 restored Iowa wetlands. Yellow-headed (*Xanthocephalus xanthocephalus*) and red-winged blackbirds (*Agelaius phoeniceus*) nested higher above the water's surface on natural than on restored wetlands. Both blackbird species nested over deeper water on natural wetlands and wetlands restored in 1988 (R-88) than on wetlands restored in 1991 (R-91). Yellowheads nesting on all three wetland types (natural, R-88, R-91), and redwings nesting on natural wetlands nested farther from shore, over deeper water, closer to the water's surface, and closer to open water in 1993 than in 1992. Redwings nested closer to shore, over shallower water, farther from open water, and in denser vegetation than yellowheads and American coots (*Fulica americana*) in all three wetland types. Red-winged blackbirds did not nest on R-91 wetlands in 1992.

# INTRODUCTION

In recent years, wetland restoration has become increasingly popular as a way to provide additional habitat for a broad range of wildlife species. However, little has been done to evaluate these newly restored wetland basins. Because providing bird nesting habitat is one of the most important wildlife functions of wetlands (Hubbard 1988), it is critical that this function be evaluated to determine if restored wetlands provide suitable habitat to meet this role.

Marsh birds, like other bird species, tend to nest in areas where their potential for reproductive success is the greatest (Ricklefs 1977). In general, marsh habitat provides breeding birds with an abundant source of food as well as emergent vegetation used as nest sites, roosting cover, and protection from predators (Orians 1980). As in other habitats, individual wetland nest-sites that provide the most benefits are selected (Burger 1985). Because restored wetland habitat may differ from that of natural wetlands (Delphey and Dinsmore 1993, VanRees-Siewert 1993), the nest-site characteristics of these wetland types may differ as well. If this is true, analysis of nest-site selection may be another way to evaluate wetland restorations and it may suggest other ways to improve wetland restorations.

The objective of this study was to analyze variables associated with nest-site selection in marsh-nesting birds in order to (1) compare nest-site selection of individual species between natural and restored Iowa wetlands, and (2) evaluate nest-site selection as a method to measure the success of wetland restorations.

# METHODS

## Study Area

I studied natural and restored wetlands in northwestern Iowa (Table A-1). Wetlands were selected based on age, size, percent emergent vegetation cover, land-use history, and degree of isolation.

I examined seven wetlands in each of three categories: unaltered natural, restored in 1988 (R-88), and restored in 1991 (R-91). Wetlands ranged from 0.8-3.0 ha (Table A-2). All wetlands selected in 1992 were in the hemi-marsh stage (40-60% emergent vegetation), the wetland type with maximum bird diversity (Weller and Spatcher 1965, Weller and Fredrickson 1974). By 1993, several of the wetlands chosen in 1992 had more than 60% emergent vegetation, but these wetlands were kept in the study to allow year-to-year comparisons. In addition, all restored wetlands selected met the following historical land-use criteria: (1) complete drainage of wetland basin prior to restoration, (2) drained with drainage tile, and (3) row cropped while basin was drained. Finally, to reduce isolation effects (Brown and Dinsmore 1986), all wetlands chosen for this study were part of wetland complexes.

## Nest Searching

I searched each wetland twice for nests in 1992, and, because of excessively high water levels, once in 1993. The entire wetland was searched systematically by foot, making parallel sweeps through emergent and upland vegetation within a few meters of the shoreline. To prevent resampling, all nests were marked by attaching a small masking tape flag to emergent vegetation 1 m from the nest. I recorded the following for each nest: species, nest contents, distance from shore (nearest 0.5m), distance to nearest open water (nearest 0.5m), height of nest rim above water (cm), depth of water at nest-site (cm), and vegetation density (dead, live, total) surrounding nest. Vegetation density was calculated by counting the number of plant stems in four 0.1-m radius circular plots located 0.5 m from the center of the nest in each of the cardinal directions. Because individual male marsh wrens (*Cistothorus platensis*) build up to an average of 22 nests (Verner and Engelson 1970), only marsh wren nests with eggs or young were sampled.

## Data Analysis

All comparisons of nest-site variables (between wetland age classes within species by year, between years within species and wetland age class, and between species within year and wetland age class) were done with t-tests. Correlations between the nest-site variables were examined using correlation analysis. Principal components analysis was used to explain variation in the nest-site variables. PC-SAS (SAS Institute Inc. 1988) statistical software and a significance level of $p \leq 0.05$ was used for all statistical tests.

# RESULTS

I found nests of ten wetland species in either 1992 or 1993 (Table 1). Only American coot (*Fulica americana*), red-winged blackbird (*Agelaius phoeniceus*), and yellow-headed blackbird (*Xanthocephalus xanthocephalus*) nests were found in sufficient abundance to allow analysis of nest-site selection.

## Comparisons Between Wetland Age Classes

In 1992, yellow-headed blackbird nest sites differed significantly among the three wetland age classes. Yellow-headed blackbirds nesting on natural and R-88 wetlands nested significantly farther from the shore than those nesting on R-91 wetlands (Table 2). Yellowhead nests on R-91 wetlands were closer to open water than nests on natural wetlands. Yellowhead nests were higher above the water's surface on natural wetlands than they were on R-88 wetlands. The water depth at yellow-headed blackbird nests was significantly different among the three wetland age classes; it was deepest on R-88 wetlands and shallowest on R-91 wetlands. The total vegetation density around yellowhead nests was greater on R-88 wetlands than on natural wetlands. Significantly more dead and less live vegetation surrounded yellowhead nests on natural wetlands than those on R-88 wetlands. R-91 nests were surrounded by live vegetation only.

Table 1. Number of nests found on natural and restored Iowa wetlands in 1992 and 1993.

| | Wetland Type | | | | | |
|---|---|---|---|---|---|---|
| | Natural | | 1988 Restored | | 1991 Restored | |
| Species | 1992 | 1993 | 1992 | 1993 | 1992 | 1993 |
| Pied-billed grebe (*Podilymbus podiceps*) | 4 | 4 | 1 | 11 | 0 | 4 |
| Canada goose (*Branta canadensis*) | 2 | 3 | 0 | 3 | 0 | 2 |
| Redhead (*Aythya americana*) | 0 | 1 | 0 | 0 | 0 | 0 |
| Ruddy duck (*Oxyura jamaicensis*) | 0 | 1 | 1 | 2 | 0 | 0 |
| Least bittern (*Ixobrychus exilis*) | 0 | 1 | 0 | 0 | 0 | 0 |
| American bittern (*Botaurus lentiginosus*) | 0 | 1 | 0 | 0 | 0 | 0 |
| American coot (*Fulica americana*) | 8 | 18 | 36 | 37 | 3 | 4 |
| Marsh wren (*Cistothorus palustris*) | 5 | 20 | 1 | 0 | 0 | 3 |
| Red-winged blackbird (*Agelaius phoeniceus*) | 46 | 86 | 3 | 16 | 0 | 9 |
| Yellow-headed blackbird (*Xanthocephalus xanthocephalus*) | 143 | 332 | 273 | 427 | 5 | 41 |

Table 2. Nest-site variables (mean±SE) for yellow-headed blackbird nests found on natural and restored Iowa wetlands, 1992 and 1993

| Variable | 1992 Natural (n=143) | 1992 R-88 (n=273) | 1992 R-91 (n=5) | 1993 Natural (n-332) | 1993 R-88 (n=427) | 1993 R-91 (n=41) |
|---|---|---|---|---|---|---|
| Distance to Shore (m) | 12.8±0.6 A[1] | 13.9±0.4 A | 6.0±0.8 B | 14.6±0.5 A | 16.0±0.3 B | 16.8±1.1 B |
| Distance to Open Water (m) | 2.9±0.3 A | 2.3±0.1 AB | 1.0±0.4 B | 1.0±0 A | 1.2±0.1 A | 2.2±0.3 B |
| Height of Nest (cm) | 55.9±0.9 A | 45.1±0.7 B | 55.2±8.1 AB | 43.3±0.6 A | 37.2±0.6 B | 38.4±1.4 B |
| Depth of Water (cm) | 52.6±1.0 A | 61.0±1.1 B | 40.1±7.4 C | 66.4±0.7 A | 74.5±1.0 B | 45.7±1.9 C |
| Vegetation Density -Dead ($\#/m^2$) | 50.2±2.4 A | 35.0±1.6 B | 0 C | 60.5±1.6 A | 50.2±1.6 B | 42.2±3.2 C |
| Vegetation Density -Live ($\#/m^2$) | 54.9±1.6 A | 79.6±2.4 B | 132.2±19.9 C | 48.6±0.8 A | 48.6±1.6 A | 84.4±8.0 B |
| Vegetation Density -Total ($\#/m^2$) | 105.1±3.2 A | 114.6±2.4 B | 132.2±19.9 AB | 109.1±2.4 A | 98.7±1.6 B | 126.6±8.0 A |

[1]Values within rows and years with different letters are statistically different, t-test, $p \leq 0.05$

In 1993, yellowhead nests in natural wetlands were closer to shore and higher above the surface of the water than both categories of restored wetlands (Table 2). Yellowhead nests on natural and R-88 wetlands were closer to open water areas than R-91 wetlands. Yellow-headed blackbirds nested over deeper water in R-88 wetlands than in natural or R-91 wetlands. Nests in both natural and R-91 wetlands had more vegetation surrounding the nest than nests in R-88 wetlands. Nests in natural wetlands were surrounded by the most dead vegetation; and R-91 wetlands by the most live.

In 1992, red-winged blackbirds nested over deeper water on R-88 wetlands than on natural wetlands (Table 3). In 1993, red-winged blackbird nests in natural wetlands were higher above the water's surface than in R-88 wetlands (Table 3). Redwing nests on natural and R-88 wetlands were placed over deeper water than redwing nests on R-91 wetlands. Total vegetation density did not differ among the three wetland types, but nests on natural wetlands were surrounded by more dead and less live vegetation than the nests on restored wetlands.

There were no significant differences in nest-site characteristics. between the three wetland-age categories for American coot nests in 1992 (Table 4). In 1993, coots nested over shallower water on R-88 wetlands than on either natural or R-91 wetlands. The vegetation density at coot nests was

Table 3. Nest-site variables (mean±SE) for red-winged blackbird nests found on natural and restored Iowa wetlands, 1992 and 1993

| | 1992 | | | 1993 | | |
|---|---|---|---|---|---|---|
| Variable | Natural (n=46) | R-88 (n=3) | R-91 (n=0) | Natural (n=86) | R-88 (n=16) | R-91 (n=9) |
| Distance to Shore (m) | 4.7±0.5 A[1] | 3.2±1.5 A | - | 4.8±0.4 A | 4.3±0.8 A | 3.9±0.7 A |
| Distance to Open Water (m) | 6.3±1.1 A | 1.3±0.7 A | - | 1.5±0.2 A | 1.3±0.2 A | 1.6±0.5 A |
| Height of Nest (cm) | 59.2±1.8 A | 51.3±11.5 A | - | 47.5±1.6 A | 37.1±3.5 B | 41.2±4.3 AB |
| Depth of Water (cm) | 31.9±2.4 A | 63.1±15.3 B | - | 40.1±1.5 A | 34.4±6.9 A | 16.4±3.1 B |
| Vegetation Density -Dead (#/m$^2$) | 38.2±4.8 A | 15.9±11.9 A | - | 74.8±4.0 A | 46.2±8.0 B | 26.3±7.2 B |
| Vegetation Density -Live (#/m$^2$) | 66.1±4.8 A | 103.5±25.5 A | - | 60.5±3.2 A | 93.9±13.5 B | 125.0±22.3 B |
| Vegetation Density -Total (#/m$^2$) | 104.3±6.4 A | 119.4±28.7 A | - | 135.4±5.6 A | 139.3±13.5 A | 151.3±19.1 A |

[1]Values within rows and years with different letters are statistically different, t-test, $p \leq 0.05$

Table 4. Nest-site variables (mean±SE) for American coot nests found on natural and restored Iowa wetlands, 1992 and 1993

| Variable | 1992 Natural (n=8) | 1992 R-88 (n=36) | 1992 R-91 (n=3) | 1993 Natural (n=18) | 1993 R-88 (n=37) | 1993 R-91 (n=4) |
|---|---|---|---|---|---|---|
| Distance to Shore (m) | 13.5±2.1 A[1] | 13.2±1.1 A | 16.3±3.2 A | 12.3±1.4 A | 10.8±0.9 A | 15.5±4.9 A |
| Distance to Open Water (m) | 1.3±0.6 A | 1.2±0.2 A | 1.0±0.3 A | 0.9±0.2 A | 0.5±0.1 A | 1.0±0.4 A |
| Height of Nest (cm) | 11.0±1.0 A | 12.3±0.7 A | 11.0±0.6 A | 12.6±1.0 A | 13.7±0.8 A | 14.0±1.7 A |
| Depth of Water (cm) | 50.7±3.5 A | 61.6±2.8 A | 49.3±3.5 A | 75.6±3.3 A | 61.5±4.4 B | 93.3±20.8 A |
| Vegetation Density -Dead (#/m²) | 0 A | 21.5±3.2 B | 2.4±2.4 AB | 43.8±5.6 A | 27.9±4.0 A | 0 B |
| Vegetation Density -Live (#/m²) | 66.9±17.5 A | 67.7±4.0 A | 71.7±16.7 A | 54.9±5.6 A | 74.8±7.2 B | 179.1±86.8 AB |
| Vegetation Density -Total (#/m²) | 66.9±17.5 A | 89.2±8.0 A | 74.0±15.1 A | 98.7±8.0 A | 101.9±7.2 A | 179.1±86.8 B |

[1]Values within rows and years with different letters are statistically different, t-test, $p \leq 0.05$

greatest on R-91 wetlands. Natural and R-88 wetlands had more dead vegetation surrounding the nest-site than R-91 wetlands, and natural wetlands had less live vegetation around coot nests than R-88 wetlands did.

## Comparisons Between Years

Except for total vegetation density, all yellow-headed blackbird nest-site characteristics measured on natural wetlands differed significantly between years. Yellowheads nested farther from shore, over deeper water, closer to an area of open water, closer to the water's surface, and in more dead and less live vegetation in 1993 than in 1992 (Table 5).

Similar results were found for yellow-headed blackbirds nesting on R-88 wetlands (Table 5). Their nests were farther from shore, over deeper water, closer to an area of open water, closer to the water's surface, and in more dead and less live vegetation in 1993 than in 1992. The only yellowhead nest-site variable difference in natural and R-88 wetlands between years was that yellowheads nested in sparser vegetation on R-88 wetlands in 1993 than in 1992. There was no difference in vegetation density of yellowhead nests in natural wetlands between years.

Three nest-site characteristics of yellow-headed blackbirds nesting on R-91 wetlands differed significantly between years. In 1993, yellowheads nested farther from

Table 5. Between-year comparisons of yellow-headed blackbird nest-site variables on natural and restored Iowa wetlands, 1992 and 1993. Values of nest-site variables are in Table 2

| | Natural | | R-88 | | R-91 | |
|---|---|---|---|---|---|---|
| Variable | 1992 | 1993 | 1992 | 1993 | 1992 | 1993 |
| Distance to Shore (m) | A[1] | B | A | B | A | B |
| Distance to Open Water (m) | A | B | A | B | A | A |
| Height of Nest (cm) | A | B | A | B | A | B |
| Depth of Water (cm) | A | B | A | B | A | A |
| Vegetation Density -Dead (#/m²) | A | B | A | B | A | B |
| Vegetation Density -Live (#/m²) | A | B | A | B | A | A |
| Vegetation Density -Total (#/m²) | A | A | A | B | A | A |

[1]Different letters within rows and wetland type are statistically different, t-test, $p \leq 0.05$

shore, closer to the surface of the water, and in more dead vegetation than in 1992 (Table 5).

Red-winged blackbird nests on natural wetlands followed the same trends seen for yellow-headed blackbirds. In 1993, redwing nests were located closer to an area of open water, nearer to the surface of the water, and over deeper water than the red-winged blackbird nests found in 1992 (Table 6). There was also denser total vegetation and more dead vegetation surrounding redwing nests in 1993 than in 1992. Redwing nest-site variables did not differ between years on R-88 wetlands (Table 6), and too few redwing nests were found on R-91 wetlands to allow analysis of nest-site characteristics (Table 1).

American coot nests in natural wetlands were in deeper water and were surrounded by more dead vegetation in 1993 than in 1992 (Table 7). In R-88 wetlands, coots nested closer to areas of open water in 1993 than in 1992.

## Comparisons Between Species

Nest-site characteristics between species within each wetland age class by year differed in several ways. On natural wetlands in 1992, both yellow-headed blackbirds and American coots nested farther from shore and over deeper water than red-winged blackbirds (Table 8). The three species differed significantly in distance from nest to open water and

Table 6. Between-year comparisons of red-winged blackbird nest-site variables on natural and restored Iowa wetlands, 1992 and 1993. Values of nest-site variables are in Table 3

| | Natural | | R-88 | | R-91 | |
|---|---|---|---|---|---|---|
| Variable | 1992 | 1993 | 1992 | 1993 | 1992 | 1993 |
| Distance to Shore (m) | A[1] | A | A | A | - | - |
| Distance to Open Water (m) | A | B | A | A | - | - |
| Height of Nest (cm) | A | B | A | A | - | - |
| Depth of Water (cm) | A | B | A | A | - | - |
| Vegetation Density -Dead ($\#/m^2$) | A | B | A | A | - | - |
| Vegetation Density -Live ($\#/m^2$) | A | A | A | A | - | - |
| Vegetation Density -Total ($\#/m^2$) | A | B | A | A | - | - |

[1]Different letters within rows and wetland type are statistically different, t-test, $p \leq 0.05$

Table 7. Between-year comparisons of American coot nest-site variables on natural and restored Iowa wetlands, 1992 and 1993. Values of nest-site variables are in Table 4

| | Natural | | R-88 | | R-91 | |
|---|---|---|---|---|---|---|
| Variable | 1992 | 1993 | 1992 | 1993 | 1992 | 1993 |
| Distance to Shore (m) | A[1] | A | A | A | A | A |
| Distance to Open Water (m) | A | A | A | B | A | A |
| Height of Nest (cm) | A | A | A | A | A | A |
| Depth of Water (cm) | A | B | A | A | A | A |
| Vegetation Density -Dead (#/m$^2$) | A | B | A | A | A | A |
| Vegetation Density -Live (#/m$^2$) | A | A | A | A | A | A |
| Vegetation Density -Total (#/m$^2$) | A | A | A | A | A | A |

[1]Different letters within rows and wetland type are statistically different, t-test, $p \leq 0.05$

Table 8. Comparison of yellow-headed blackbird, red-winged blackbird, and American coot nest-site variables on natural and restored Iowa wetlands, 1992

| | Natural | | | R-88 | | | R-91 | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | YHB[1] | RWB | AMC | YHB | RWB | AMC | YHB | RWB | AMC |
| Distance to Shore (m) | A[2] | B | A | A | B | A | A | - | B |
| Distance to Open Water (m) | A | B | C | A | AB | B | A | - | A |
| Height of Nest (cm) | A | A | B | A | AB | B | A | - | B |
| Depth of Water (cm) | A | B | A | A | A | A | A | - | A |
| Vegetation Density -Dead (#/$m^2$) | A | B | C | A | AB | B | A | - | A |
| Vegetation Density -Live (#/$m^2$) | A | B | AB | A | A | B | A | - | A |
| Vegetation Density -Total (#/$m^2$) | A | A | B | A | AB | B | A | - | A |

[1]YHB=Yellow-headed blackbird, RWB=Red-winged blackbird, AMC=American coot
[2]Different letters within rows and wetland type are statistically different, t-test, $p \leq 0.05$

the density of dead vegetation surrounding the nest. Redwings nested farthest from an area of open water; coots were closest. Yellowhead nests were located in the densest areas of dead vegetation; coots in the sparsest. Although the total vegetation density surrounding redwing and yellowhead nests was similar, redwing nests were surrounded by more live vegetation than yellowhead nests. The amount of total vegetation surrounding coot nests was less than that surrounding redwing and yellowhead nests.

Several of the trends shown in natural wetlands in 1992 were found in 1993. Yellowheads and coots nested farther from shore, closer to open water, and in areas of sparser vegetation than redwings (Table 9). Redwing nests were higher above the surface of the water than yellowhead nests. Each species had different water depths and densities of dead vegetation at the nest-site. The water was deepest and the dead vegetation sparsest at American coot nests. Redwings nested over the shallowest water and in the densest live and dead vegetation.

Similar to the redwing nests on natural wetlands, red-winged blackbird nests on R-88 wetlands were significantly closer to shore than either yellowhead or coot nests in 1992 (Table 8). American coot nests were closer to open water and in areas of sparser vegetation than yellow-headed blackbird nests.

Table 9. Comparison of yellow-headed blackbird, red-winged blackbird, and American coot nest-site variables on natural and restored Iowa wetlands, 1993

| | Natural | | | R-88 | | | R-91 | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | YHB[1] | RWB | AMC | YHB | RWB | AMC | YHB | RWB | AMC |
| Distance to Shore (m) | A[2] | B | A | A | B | C | A | B | AB |
| Distance to Open Water (m) | A | B | A | A | A | B | A | A | A |
| Height of Nest (cm) | A | B | C | A | A | B | A | A | B |
| Depth of Water (cm) | A | B | C | A | B | C | A | B | A |
| Vegetation Density -Dead (#/m²) | A | B | C | A | A | B | A | A | B |
| Vegetation Density -Live (#/m²) | A | B | AB | A | B | B | A | A | A |
| Vegetation Density -Total (#/m²) | A | B | A | A | B | A | A | A | A |

[1]YHB=Yellow-headed blackbird, RWB=Red-winged blackbird, AMC=American coot
[2]Different letters within rows and wetland type are statistically different, t-test, $p \leq 0.05$

In 1993, two nest-site variables differed for all three species nesting on R-88 wetlands. Yellow-headed blackbird nests were farther from shore and over deeper water than both redwing and coot nests (Table 8). Red-winged blackbirds nested closer to shore, over shallower water, and in denser vegetation than both yellowheads and coots. American coot nests were closer to open water areas than both redwings and yellowheads. Redwing and yellowhead nests were surrounded by more dead vegetation than coot nests, and yellowhead nests were surrounded by the least amount of live vegetation.

The only difference in nest-site variables in R-91 wetlands in 1992 was that American coots nested farther from shore than yellow-headed blackbirds (Table 8). In 1993, yellowheads nested farther from shore than redwings, and both blackbird species nested in areas of denser dead vegetation than did coots (Table 9). Yellowhead and coot nests were over deeper water than redwing nests.

## Correlation and Principal Component Analyses

A correlation analysis of the nest-site variables showed that the only variables that were correlated were distance of the nest from shore and the depth of water at the nest-site ($r^2 = 0.34$). Principal component analysis was not a useful descriptor of these data because the principal components did not adequately account for the variation in the nest-site variables.

# DISCUSSION

As highly dynamic ecosystems, wetlands undergo frequent, and often dramatic, fluctuations in water levels and vegetative structure. Drought, followed by the reflooding of a wetland basin in subsequent wet years, is a classic example of the changes caused by year-to-year weather variations. Such changes have a dramatic effect on the distribution and abundance of marsh birds (Weller and Spatcher 1965, Weller and Fredrickson 1974).

Although many authors describe both red-winged and yellow-headed blackbirds as "typical" marsh birds, redwings are capable of nesting in a variety of habitats, whereas yellowheads are restricted to deep, semi-permanent wetlands (Weller and Spatcher 1965, Miller 1968). Since redwings can better tolerate changing conditions and persist even under extreme conditions, yellowheads are considered to be good indicators of productive wetland habitat (Weller and Spatcher 1965, Weller 1969, Weller and Fredrickson 1974).

The restoration of previously drained wetland basins may mimic the drought/reflooding cycle of natural wetlands. If birds respond to the process of wetland restoration and the drought/reflooding cycle in a similar way, we would expect newly restored wetlands to be colonized by red-winged blackbirds first and followed in later years by other marsh bird species (Weller and Spatcher 1965, Weller and Fredrickson 1974). My data did not support this assumption, however, as no redwings, but both yellowheads and coots nested on 1-year-old restored wetlands in my study (Table 1). Perhaps the habitat available for nesting marsh birds in these newly restored wetlands was of high enough quality to permit the establishment of yellowhead territories. Because yellowheads are known to dominate redwings in competitive situations (Orians 1961, Orians and Willson 1964, Miller 1968, Voigts 1973, Minock 1983), the yellowheads may have prevented redwings from nesting on these 1-year-old restored wetlands; wetlands with limited nesting habitat available for breeding blackbirds (see Paper I). The presence of American coots on these newly restored wetlands is less surprising than that of the yellowheads because coots require moderate plant density and open water for nesting (Weller and Spatcher 1965); habitat abundant on the R-91 wetlands.

Even though several yellow-headed blackbirds nested on R-91 wetlands in 1992, they nested closer to shore, closer to open water, and in shallower water than yellowheads nesting on the other two wetland types (Table 2). This suggests that the habitat provided by the three wetland types differs qualitatively. A common theory for why birds nest in marshes is that mammalian predation is reduced (Robertson 1973, Caccamise 1977, Burger 1985, Picman et al. 1993). Because the characteristics that presumably reduce mammalian predation in wetland ecosystems (increased distance from land, deep water, and dense vegetation) may be missing in the R-91 wetlands, this benefit may not be realized in R-91 wetlands during their first year of being reflooded.

Even though several yellowhead nest-site variables of natural and R-91 wetlands still differed in 1993, by the second year of the study, yellowhead nests on R-91 wetlands were farther from shore and were surrounded by more dead vegetation than they had been in 1992 (Table 5). These changes suggest that even though some differences in the nesting habitat provided by natural and R-91 wetlands remain, by their second year, restored wetlands offer habitat more similar to that provided by natural wetlands than they do in their first year following restoration.

Yellowheads, redwings, and coots nesting on all three wetland types nested over deeper water in 1993 than they did in 1992. If nesting over deeper water reduces mammalian predation (Picman et al. 1993), my results suggest that these species selected for "safer" nest-sites in 1993. When considering the differences in rainfall levels between 1992 and 1993, however, this conclusion becomes unlikely. Total spring rainfall (April-June) in Dickinson and Emmet counties was below the 30-year average (-2.69 and -6.04 cm respectively) in 1992 and far above the 30-year average

(+32.49 and +37.81 cm respectively) in 1993 (NOAA 1992, 1993). Another variable that may have been affected by an increased water-level in 1993 is the height of the nest above the water's surface. Once nest-site selection occurs and a blackbird nest is woven into emergent vegetation, its distance from the substrate is fixed; the deeper the water becomes, the closer the nest is to the surface of the water. In 1993, in addition to being located over deeper water, both redwing and yellowhead nests were closer to the water's surface on all three wetland types. This suggests that both water depth and nest height are closely related to precipitation levels. Although it is possibile that the birds selected for deeper water in 1993, it is more likely that the water was simply deeper and the data reflected this fact.

In addition to causing an increase in the mean water depth at the nest-site and a decrease in the height of the nest above the water's surface, daily fluctuations in water levels caused by frequent precipitation may have caused a greater amount of variation in the values collected for these two variables in 1993 than was present in 1992. If the day-to-day variability in these nest-site measurements was greater in 1993, it becomes even more difficult to make conclusions regarding the depth of the water at the nest-site and the height of the nest between years.

It is, however, interesting that yellowhead nests in natural wetlands were significantly higher above the water's surface than those in R-88 wetlands in both years (Table 2). This may reflect a difference in the vegetation structure. Although the total vegetation density surrounding yellowhead nests on natural and R-88 wetlands did not differ in 1992, the density of dead vegetation around yellowhead nests was greater in the natural wetlands than in both categories of restored wetlands for both years (Table 2). In 1993, the density of dead vegetation surrounding redwing nests was greater on natural than restored wetlands. Blackbird nests are often placed in dead vegetation because nesting is initiated before green vegetation is available (Weller and Spatcher 1965). Many blackbird nests attached to live plant stems are tipped and their contents spilled because the plant stems grow at different rates (Weller and Spatcher 1965, pers. observ.). Such losses favor the use of dead stems over live for nest support. My results suggest that the blackbirds select for dead vegetation, although this cannot be assumed with any degree of certainty because the availability of dead vegetation increases as wetlands age.

Although wetland vegetation shows little vertical stratification, small differences in plant density and water depth provide marsh birds with the opportunity to stratify the habitat enough to form territories and nest sites (Burger

1985). A comparison of yellow-headed blackbird, red-winged blackbird, and American coot spatial nest-site segregation on the three wetland types may give us an idea of whether or not restored wetlands are comparable to natural wetlands in terms of providing adequate nesting habitat.

In this study, yellow-headed blackbirds nested significantly farther from shore than red-winged blackbirds on all three wetland types in both years (Tables 8,9). Numerous studies show that redwings and yellowheads maintain mutually exclusive territories (Orians and Willson 1964, Weller and Spatcher 1965, Miller 1968, Voights 1973).

I also found that yellow-headed blackbirds nested over deeper water, closer to an area of open water, and in areas of sparser vegetation than red-winged blackbirds (Tables 8,9). Many studies show that even though earlier returning redwings set up territories encompassing all emergent vegetation in a marsh, the later returning yellowheads displace them, moving them from parts of the marsh that are deeper and have less vegetation to more marginal habitat at the wetland edge (Orians and Willson 1964, Weller and Spatcher 1965, Miller 1968, Voights 1973).

Most American coot nest-site characteristics were similar to those of yellow-headed blackbirds within wetland types. Coots nested approximately the same distance from shore, over the same water depth, and in the same vegetation density as did yellow-headed blackbirds (Tables 8,9). Coot nests were also either the same distance from, or closer to, areas of open water. Coots require areas of open water near their nests because they must be able to swim to them (Weller and Spatcher 1965).

Overall, there were no major pattern differences in the nest-site characteristics of the yellowheads, redwings, and coots nesting on the three different wetland types. This is encouraging because it suggests that both new and older restored wetlands provide yellowheads, redwings, and coots with nesting habitat that is comparable to that provided by natural wetlands. Furthermore, it appears that the analysis of nest-site characterisitics may be another useful tool in evaluating the success of wetland restorations.

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# GENERAL SUMMARY AND DISCUSSION

Wetland restoration is an attempt to reverse centuries of habitat destruction. As an ecosystem that is important to humans and wildlife alike, it is crucial that we attempt to replace the millions of acres of wetland habitat that have been lost to agricultural, industrial, and residential development. Replacement of this habitat may be easier planned than accomplished, however.

Several studies of wetland restoration have shown that, at least within the first few years of restoration, these restored habitats are significantly different from natural wetlands in terms of bird use (Delphey and Dinsmore 1993, Hemeseth and Dinsmore 1993, VanRees-Siewert 1993). These studies have shown, however, that as restored wetlands age, the number of breeding bird species using them increases. My results showed this trend as well.

I found that natural and older restored wetlands support similar numbers of breeding birds as well as provide similar nesting habitat. Younger restored wetlands (1- and 2-year-old basins) had fewer breeding bird species and less nesting habitat than natural and older restored wetlands.

Species comparison and guild analysis of breeding bird communities of natural and restored wetlands showed that even though natural and older restored wetlands can support similar numbers of breeding bird species, the community structure of these two wetland types is quite different. Natural wetlands supported more breeding marsh wrens (*Cistothorus palustris*), swamp sparrows (*Melospiza georgiana*), soras (*Porzana carolina*), and Virginia rails (*Rallus limicola*) than either category of restored wetland. The absence of these species in restored wetlands may be related to the lack of a wet-meadow zone (Delphey 1991, Galatowitsch 1993, VanRees-Siewert 1993), which was present in all of the natural wetlands in the study.

Despite the breeding-bird community differences between natural and older restored wetlands, however, the fact that restored wetlands can support a similar number of species is encouraging. Perhaps as restored wetlands continue to age, the microhabitats required by more specialized marsh birds will develop. It is important, therefore, that we continue to monitor restored wetlands as they age as well as continue to investigate the differences between natural and restored wetlands with the hope that our efforts to restore a damaged habitat are realized.

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